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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1 53(b))

Attorney Docket No.	500.38949X00
First Inventor or Application Identifier	Tomio IWASAKI, ET AL.
Title	SEMICONDUCTOR DEVICE
Express Mail Label No.	

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents

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1. [X] * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original and a duplicate for fee processing)
2. [X] Specification [Total Pages 20] (preferred arrangement set forth below)
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) (35 U.S.C. 113) [Total Sheets 10]
4. Oath or Declaration [Total Pages 5]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 16 completed)
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

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5. [ ] Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement (when there is an assignee) [X] Power of Attorney
9. [ ] English Translation Document (if applicable)
10. [X] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. [ ] * Small Entity Statement(s) (PTO/SB/09-12) [ ] Statement filed in prior application Status still proper and desired
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SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

The invention relates to a semiconductor device and a method for producing the same.

In recent years, due to the miniaturization of semiconductor devices, the width of metal conductor tends to become small. Thus, to prevent an aluminum conductor from being broken due to migration and to prevent hillock from occurring due to the migration, there has been generally used a method of adding copper of about 0.5% in aluminum used for the aluminum conductor. However, the spacing of metal conductor portions as well as the metal conductor width tends to also become small. Thus, if any precipitate containing copper exists between two metal conductor portions, it becomes the cause of short fault. To address this problem, it is proposed, in JP-A-8-186175 and etc., to adopt a method comprising the steps of forming aluminum film at a high temperature so that copper may be dissolved in aluminum, and quenching the aluminum film so that the copper may be prevented from being precipitated during the cooling thereof.

SUMMARY OF THE INVENTION

The conventional method in which aluminum conductor containing copper is formed by use of the quenching treatment, is not sufficient when the spacing

between aluminum conductor portions adjacent to each other (hereinafter referred to as "conductor spacing") becomes further narrow to be not more than 0.4 μm.

Thus, the first object of the invention is to provide a semiconductor device having high reliability.

The second object of the invention is to provide a semiconductor device having a high yield.

The third object of the invention is to provide a semiconductor device having such interconnect structure as short hardly occurs.

The precipitation of copper regarding the aluminum conductor is found to proceed due to the diffusion of copper atoms existing in crystal grain boundaries and in crystal grains. Thus, in order to prevent the precipitation from occurring, it is necessary to suppress the diffusion of the copper atoms existing in the aluminum conductor. After performing intensive researches for obtaining means for suppressing the diffusion of the copper atoms, the inventors of the invention have discovered that, by adding in the aluminum conductor an additive which suppresses the diffusion of copper, the precipitation can be prevented.

The subjects of the invention can be solved by a semiconductor device having any one of the following constitutions 1 to 5:

(1) a semiconductor substrate, and aluminum conductor containing aluminum as the main constituent thereof which aluminum conductor is provided on the side

of one main face of the substrate, the aluminum conductor being made to contain copper and nickel therein. Further, it is preferred that in some region of the semiconductor device, the conductor spacing is not more than 0.4 μm and that the content of the nickel is not less than 0.02 at.% but not more than 1 at.%;

(2) a semiconductor substrate, aluminum conductor containing aluminum as the main constituent thereof which aluminum conductor is provided on the side of one main face of the substrate, and adjacent film (barrier film) adjacent to the aluminum conductor which adjacent film containing titanium and titanium nitride as the main constituents thereof, the aluminum conductor being made to contain copper and nickel therein. Further, it is preferred that in some region of the semiconductor device, the conductor spacing is not more than 0.4 μm and that the content of the nickel is not less than 0.02 at.% but not more than 1 at.%;

(3) a semiconductor substrate, and aluminum conductor containing aluminum as the main constituent thereof which aluminum conductor is provided on the side of one main face of the substrate, the aluminum conductor being made to contain copper and silicon therein. Further, it is preferred that in some region of the semiconductor device, the conductor spacing is not more than 0.4 μm and that the content of the silicon is not less than 0.05 at.% but not more than 0.4 at.%;

(4) a semiconductor substrate, aluminum

conductor containing aluminum as the main constituent thereof which aluminum conductor is provided on the side of one main face of the substrate, and adjacent film (barrier film) adjacent to the aluminum conductor which adjacent film containing titanium and titanium nitride as the main constituents thereof, the aluminum conductor being made to contain copper and silicon therein; and

(5) a semiconductor substrate, aluminum conductor containing aluminum as the main constituent thereof which aluminum conductor is provided on the side of one main face of the substrate, and adjacent film (barrier film) adjacent to the aluminum conductor which adjacent film containing one kind selected from the group consisting of ruthenium, platinum and iridium as the main constituent thereof, the aluminum conductor being made to contain copper. Further, it is preferred that nickel not less than 0.02 at.% but not more than 1 at.% is contained in the aluminum conductor and that silicon not not less than 0.05 at.% but not more than 0.4 at.% is contained in the aluminum conductor.

In the specification, the main constituent of the metal conductor means a component contained in the metal conductor the amount of which component is the largest in the metal conductor.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a sectional view of the main part of a semiconductor device according to the first embodiment of

the invention.

Fig.2 is a graph showing the dependence of the diffusion coefficient of aluminum upon copper content with respect to a low content range of copper.

Fig.3 is a graph showing the dependence of the diffusion coefficient of aluminum upon copper content with respect to a high content range of copper.

Fig.4 is a graph showing the dependence of the precipitation rate of copper upon nickel content with respect to a low content range of nickel.

Fig.5 is a graph showing the dependence of the precipitation rate of copper upon nickel content with respect to a high content range of nickel.

Fig.6 is a graph showing the dependence of the precipitation rate of copper upon silicon content with respect to a low content range of silicon.

Fig.7 is a graph showing the dependence of the precipitation rate of copper upon silicon content with respect to a high content range of silicon.

Fig. 8 is a sectional view of the main part of another semiconductor device according to the second embodiment of the invention.

Fig. 9 is a graph showing the dependence of copper precipitation rate upon the kind of materials used for a barrier film in a case where an aluminum film containing copper and nickel is in contact with the barrier film.

Fig. 10 is a graph showing the dependence of

copper precipitation rate upon the kind of materials used for the barrier film in a case where an aluminum film containing copper and silicon is in contact with the barrier film.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENITON

The embodiments of the invention are explained in detail below while referring to the drawings.

First, the sectional structure of the main part of a semiconductor device according to the first embodiment of the invention is shown in Fig. 1. In the semiconductor device according to the first embodiment, as shown in Fig. 1, diffusion layers 2, 3, 4 and 5 are formed on a silicon substrate 1, on which layers are formed gate dielectrics 6 and 7 and gate electrodes 8 and 9, so that MOS transistors are formed. Each of the gate dielectrics 6 and 7 is, for example, made of silicon oxide film or silicon nitride film, and each of the gate electrodes 8 and 9 is, for example, made of polycrystalline silicon film or metal thin film or metal silicide film or layered structure of these films. The MOS transistors are separated by an isolation film 10 of, for example, silicon oxide film. On the upper portion and side wall of the gate electrodes 8 and 9, there are formed insulating films 11 and 12 which are made of, for example, silicon oxide film. On the whole, upper faces of the MOS transistors is formed an insulating film 13

made of, for example, BPSG (Boron-Doped Phospho Silicate Glass) film, or SOG (Spin On Glass) film, or silicon oxide or silicon nitride film formed by chemical vapor deposition method or sputtering method. In contact holes formed in the insulating film 13, there are formed plugs each comprising a main conductive film 15 coated with adjacent conductive film 14a, 14b (first conductive film) for preventing diffusion, each of which plugs is connected to each of the diffusion layers 2, 3, 4 and 5. To the plugs is connected the first layered interconnection comprising a main conductive film 17 coated with adjacent conductive films 16a and 16b for preventing diffusion. The layered interconnection is, for example, provided by the steps of forming the main conductive film 17 by use of a sputtering process after having formed the adjacent conductive film 16a by the sputtering process, forming thereon the adjacent conductive film 16b by the sputtering process, and forming an interconnect pattern by the etching thereof. If precipitates containing copper remain during the etching without being removed, short will occurs in a case where the conductor spacing 28 is narrow. On the first layered interconnection, plugs each comprising a main conductive film 20 coated with an adjacent conductive film 19 are formed in contact holes formed in insulating film 21. To these plugs is connected the second layered interconnection which comprises a main conductive film 23 coated with adjacent conductive films

22a and 22b. The second layered interconnection is, for example, provided by the steps of forming the main conductive film 23 by sputtering after having formed the adjacent conductive film 22a by sputtering, forming thereon the adjacent conductive film 22b by sputtering, and forming an interconnect pattern by the etching thereof.

The materials of the main conductive film 17 and the main conductive film 23 respectively provided in the first and second layered interconnections are, for example, aluminum, in which copper is added to provide good migration resistance. In the embodiment, in order for short not to occur due to the precipitation of copper even in the case where the conductor spacings 28 and 29 are not more than 0.4 μm, at least one kind selected from the group consisting of nickel and silicon is added to each of the main conductive film 17 and the main conductive film 23. As the method of the adding, there is used, for example, sputtering using a target of alloy or multi-sputtering using a plurality of targets. As regards the contents of copper, nickel and silicon, they are explained below in connection with the effect brought about in the embodiments of the invention.

For explaining in detail the effect brought about in the embodiments, there are shown analysis examples by use of molecular dynamics simulation. The molecular dynamics simulation is, as disclosed, for example, in Journal of Applied Physics Vol. 54, pages

4864 to 4878, issued in 1983, a method in which force acting on each of atoms is calculated through potential among the atoms and in which, by solving Newton's Equation of Motion, the location of each atom at each time is calculated.

In the embodiment, by calculating the interaction among different elements by introducing the transfer of electric charge in the above-explained molecular dynamics, the relations explained below can be obtained.

The main effect of the embodiment is to make it possible to prevent the precipitation of copper by adding nickel and/or silicon, and the respect that the adding of copper is effective for preventing the migration had been already known. However, in order to restrict the content of copper into a proper value, the dependence of the migration-preventing effect upon the copper content is disclosed at first. The "migration" is a phenomenon that aluminum atoms are diffused due to the influences of heat, stress and electric current with the result that voids and/or hillocks are caused, and the larger the diffusion coefficient is, the more the migration becomes apt to occur. Thus, the migration-preventing effect can be shown by the rate of decrease in the diffusion coefficient. As regards the method for calculating the diffusion coefficient by use of the molecular dynamics simulation, it is disclosed in Physical Review B Vol. 29 (issued in 1984), pages 5363 to 5371.

In Figs. 2 and 3 are disclosed the results of analyzing the dependence of the gain boundary diffusion coefficient D_{GB} of aluminum atoms existing in the grain boundaries of aluminum crystalline upon the content of copper, and the dependence of the intra-grain diffusion coefficient D_{IN} of aluminum atoms existing in the interior of aluminum crystalline upon the content of copper. In Figs. 2 and 3, the results are shown while marking with D_{GB0} and D_{IN0} the grain boundary diffusion coefficient and the intra-grain diffusion coefficient both in the case of no copper added, respectively. As apparent from Fig. 2, the diffusion-suppressing effect becomes remarkable when the copper content becomes not less than 0.01 at.%, and this effect becomes saturated when the copper content is 0.02 at.%. Further, as apparent from Fig.3, the diffusion-suppressing effect becomes lowered when the copper content exceeds 2 at.%, which occurs because, if the additives are excessively added, the crystal structure of aluminum which is the main constituent is disturbed with the result that the diffusion becomes active. Thus, in order to enhance the migration resistance, the copper content is preferred to be not less than 0.02 at.% but not more than 2 at.%. These are the results of the analysis at 700°K at which copper is in a solid solution state in aluminum crystalline. In the case of 500°K, although the precipitation of copper is observed, the Cu-adding effect can be shown similarly even in this case. Further, even

at other temperatures, similar effects can be also shown.

Next, the effect of preventing copper from being precipitated in a case of adding nickel is explained below. There was performed a simulation in which copper was precipitated while setting the temperature at 500°K, and the results of analyzing the dependence of precipitation rate V upon nickel content are shown in Figs. 4 and 5. In Figs. 4 and 5, the precipitation rate in a case where no nickel was added is marked as "V_0". The precipitation rate in the simulation means such a rate as, at portions in aluminum crystalline where copper atoms gathered, other copper atoms further gather, and is defined as the number of copper atoms gathering per a unit period of time. As shown in Fig. 4, when the nickel content becomes not less than 0.008 at.%, the effect of preventing the precipitation of copper becomes remarkable, and the effect becomes substantially saturated when the nickel content is 0.02 at.%. Further, as apparent in Fig. 5, when the nickel content exceeds 1 at.%, the effect of preventing the precipitation of copper becomes small. Thus, in order to prevent the precipitation of copper, it is preferred that the nickel content is not less than 0.02 at.% but not more than 1 at.%.

Then, the effect of preventing copper from being precipitated in a case of adding silicon is explained below. There was performed a simulation in which copper was precipitated while setting the

temperature at 500°K, and the results of analyzing the dependence of precipitation rate V upon silicon content are shown in Figs. 6 and 7. In Figs. 6 and 7, the precipitation rate in a case where no silicon was added is marked as "V_0". As shown in Fig. 6, when the silicon content becomes not less than 0.02 at.%, the effect of preventing the precipitation of copper becomes remarkable, and the effect becomes substantially saturated when the silicon content is 0.05 at.%. Further, as apparent in Fig. 7, when the silicon content exceeds 0.4 at.%, the effect of preventing the precipitation of copper becomes small. Thus, in order to prevent the precipitation of copper, it is preferred that the silicon content is not less than 0.05 at.% but not more than 0.4 at.%.

Incidentally, in prior arts, in order to prevent aluminum conductor from absorbing silicon atoms from the silicon substrate and/or the silicon oxide film, it had been known to add silicon of about 1 at.% in the aluminum conductor. However, it is impossible to prevent the precipitation of copper insofar as this amount of the conventionally added silicon is concerned.

In the case of a temperature other than 500°K, the effects of nickel and silicon can be also shown insofar as the temperature is such one as the copper can be precipitated. At a temperature not more than 350°K, the precipitation of copper became very slow in rate so that it was impossible to confirm the precipitation of

copper in the simulation. Further, in another case where the temperature becomes such a high temperature as to be not less than 550°K, the copper is apt to be dissolved, so that the precipitation thereof hardly occurs. In the range between 350°K and 550°K, the precipitation of copper is most apt to occur. Thus, in order to prevent the precipitation of copper, it is more preferred that both of the method of adding nickel and/or silicon and the method of quenching down to a temperature not more than 350°K after forming a film at another temperature not less than 550°K are combined. In the specification, the term "quenching" means a cooling performed at a rate larger than the rate of natural cooling occurring by leaving a sample as it is. In order to perform the quenching, there are used, for example, gases or fluid for cooling. Further, in order to realize prior to the quenching a state in which copper is sufficiently dissolved, it is preferred to perform the quenching after keeping a high temperature for a period of time of, for example, not less than 5 seconds following the completion of the deposition of the atoms. In a case where a heat treatment is performed before forming interconnection pattern by etching etc. after the quenching, it is preferred to perform the heat treatment at such a high temperature as to be not less than 550°K and to perform the quenching when cooling.

In comparing Fig. 4 with Fig. 6, it is found that nickel is more effective than silicon regarding the

precipitation-preventing effect. Further, it become possible to make the aluminum conductor lower in resistance in the case of adding nickel than in the case of adding silicon. On the other hand, the addition of silicon has such an effect as to prevent the aluminum conductor from absorbing silicon atoms from the silicon substrate and/or the silicon oxide film.

Next, regarding another semiconductor device relating to the second embodiment of the invention, the sectional structure of the main parts thereof is shown in Fig. 8. The difference between the second embodiment and the first embodiment resides in the respect that, in the first and second layered interconnections, still other barrier films 26a and 26b; 27a and 27b are formed outside of the barrier films 16a and 16b; 22a and 22b of the main conductive films 17 and 23, respectively. Alternatively, although not shown in the drawings, other barrier films of at least one layer may be formed at the outside of the outermost films. Further, the numbers of the layers of the barrier film regarding each of the main conductive films 17 and 23 may be different from each other. In addition, the number of each of the upper and lower layers of the barrier films each provided regarding the main conductive films 17 and 23 may be different from each other. In the case where each of the main conductive films 17 and 23 is made of an aluminum alloy containing copper as an additive, the respect that nickel and/or silicon is preferably added therein to prevent the

precipitation of copper is the same as in the first embodiment. In order to further make the copper precipitation hardly occur, it is preferred that the main constituent of each of the barrier films 16a, 16b, 22a and 22b is one kind selected from the group consisting of ruthenium, platinum and iridium. The effect brought about by using as a barrier film material the one kind selected from the group consisting of ruthenium, platinum and iridium is explained below. In Figs. 9 and 10 are shown the results of analyzing the precipitation rate of copper in a case of making the barrier film in contact with the aluminum film. In Fig. 9, the results are shown in a case where the copper and nickel contents are 0.5 at.% and 0.1 at.%, respectively. In Fig. 10, the results are shown in another case where the copper and silicon contents are 0.5 at.% and 0.1 at.%, respectively. In Figs. 9 and 10, the precipitation rate in the case of using titanium nitride as a usually used barrier film is set to be V_{TiN}. From Figs. 9 and 10, it is apparent that, in the case where the one kind selected from the group consisting of ruthenium, platinum and iridium is used as the material of the barrier film, the precipitation of copper is more suppressed in comparison with the case of using titanium nitride as the barrier film. When using the one kind selected from the group consisting of ruthenium, platinum and iridium as the barrier films 16a, 16b, 22a and 22b, it is preferred to use, for improving the adhesion thereof to the insulating films 13, 21 and

25, the films of titanium nitride or titanium or the layered film thereof regarding the barrier films 26a, 26b, 27a and 27b. As regards the main conductive film of the plugs, aluminum in which copper and nickel are added or in which copper and silicon are added may be used, or another material such as, for example, tungsten or silicon may be used. Further, without using the copper-and-nickel-added aluminum or the copper-and-silicon-added aluminum regarding the whole of the film for forming the interconnection, a part of the whole film may be formed by use of one of these Al alloys.

According to the invention, it becomes possible to provide a semiconductor device having high reliability, to provide a semiconductor device having high yield, and to provide a semiconductor device having such an interconnection structure as short hardly occurs.

WHAT IS CLAIMED IS:

1. A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side of a main face of the substrate which aluminum conductors comprises aluminum as main constituent thereof, said aluminum conductors containing copper and nickel.

2. A semiconductor device according to claim 1, wherein said aluminum conductors has at least one area in which conductor spacing is not more than 0.4 μm.

3. A semiconductor device according to claim 2, wherein the content of nickel contained in said aluminum conductors is not less than 0.02 at.% but not more than 1 at.%.

4. A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side of a main face of the substrate which aluminum conductors comprise aluminum as main constituent thereof, a film adjacent to said aluminum conductors which adjacent film comprises titanium or titanium nitride as main constituent thereof, said aluminum conductors containing copper and nickel.

5. A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side of a main face of the substrate which aluminum conductors comprise aluminum as main constituent thereof, said aluminum conductors containing copper and silicon.

6. A semiconductor device according to claim 5,

wherein said aluminum conductors has at least one area in which conductor spacing is not more than 0.4 μm.

7. A semiconductor device according to claim 6, wherein the content of silicon contained in said aluminum conductors is not less than 0.05 at.% but not more than 0.4 at.%.

8. A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side of a main face of the substrate which aluminum conductors comprise aluminum as main constituent thereof, a film adjacent to said aluminum conductors which adjacent film comprises titanium or titanium nitride as main constituent thereof, said aluminum conductors containing copper and silicon.

9. A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side of a main face of the substrate which aluminum conductors comprises aluminum as main constituent thereof, said aluminum conductors having at least one area in which conductor spacing is not more than 0.4 μm, a film adjacent to said aluminum conductors which adjacent film comprises one kind selected from the group consisting of ruthenium, platinum and iridium as main constituent thereof, said aluminum conductors containing copper.

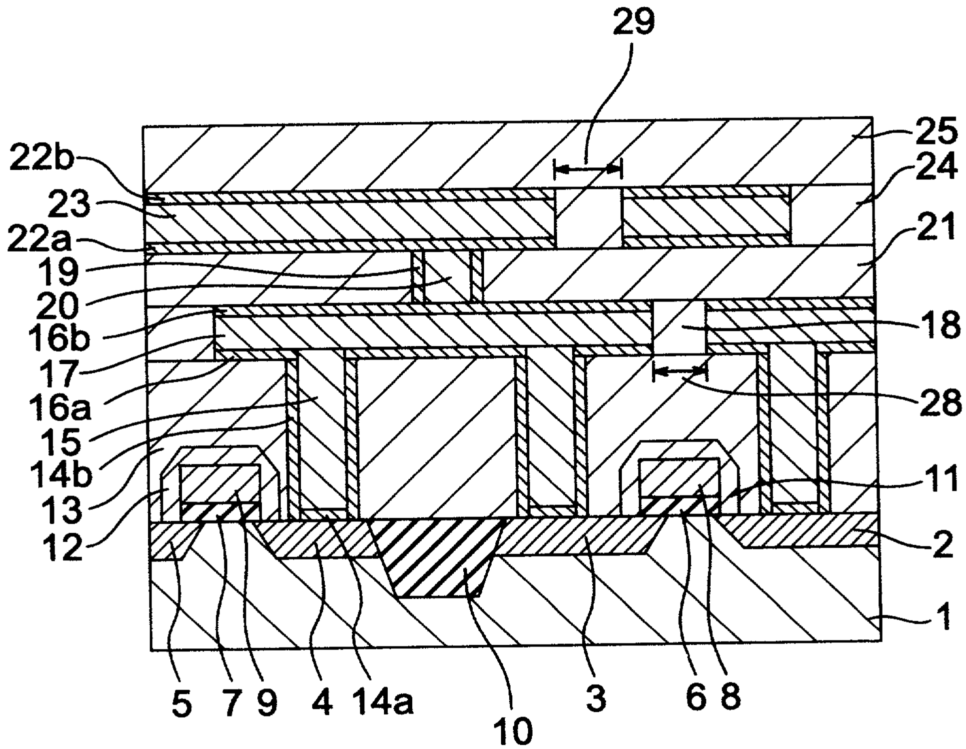
10. A semiconductor device according to claim 9, wherein said aluminum conductors contain nickel not less than 0.02 at.% but not more than 1 at.%.

11. A semiconductor device according to claim 9, wherein said aluminum conductors contain silicon not less than 0.05 at.% but not more than 0.4 at.%.

ABSTRACT OF THE DISCLOSURE

There is provided a semiconductor device having high reliability, high yield, and such a interconnection structure as short hardly occurs. The semiconductor device comprises a semiconductor substrate, metal conductors formed on a side of a main face of the substrate which metal conductors contain aluminum as main constituent thereof and copper as an additive element, the metal conductors being made to contain such an element as to suppress the precipitation of copper or being made to have such a film adjacent to the metal conductor as to suppress the precipitation of copper.

FIG. 1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23
22a
19
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14a
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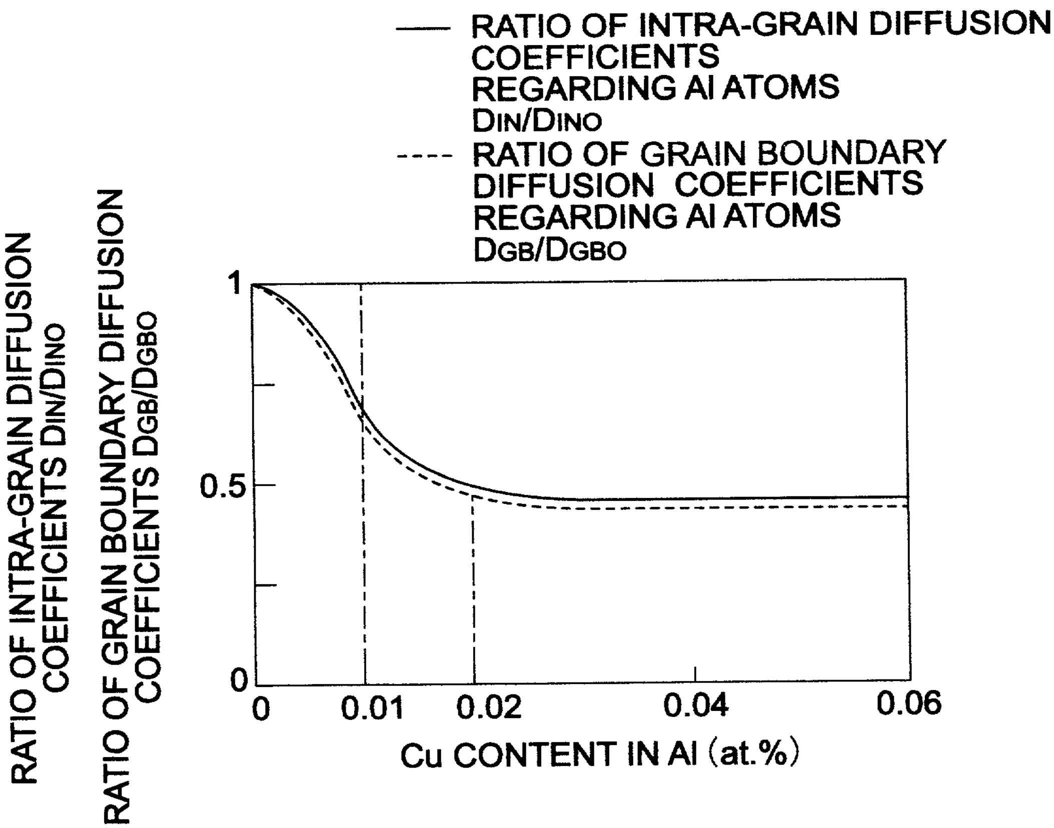
8

FIG. 2



RATIO OF INTRA-GRAIN DIFFUSION COEFFICIENTS REGARDING Al ATOMS DIN/DINO
RATIO OF GRAIN BOUNDARY DIFFUSION COEFFICIENTS REGARDING Al ATOMS DGB/DGBO
RATIO OF INTRA-GRAIN DIFFUSION COEFFICIENTS DIN/DINO
RATIO OF GRAIN BOUNDARY DIFFUSION COEFFICIENTS DGB/DGBO
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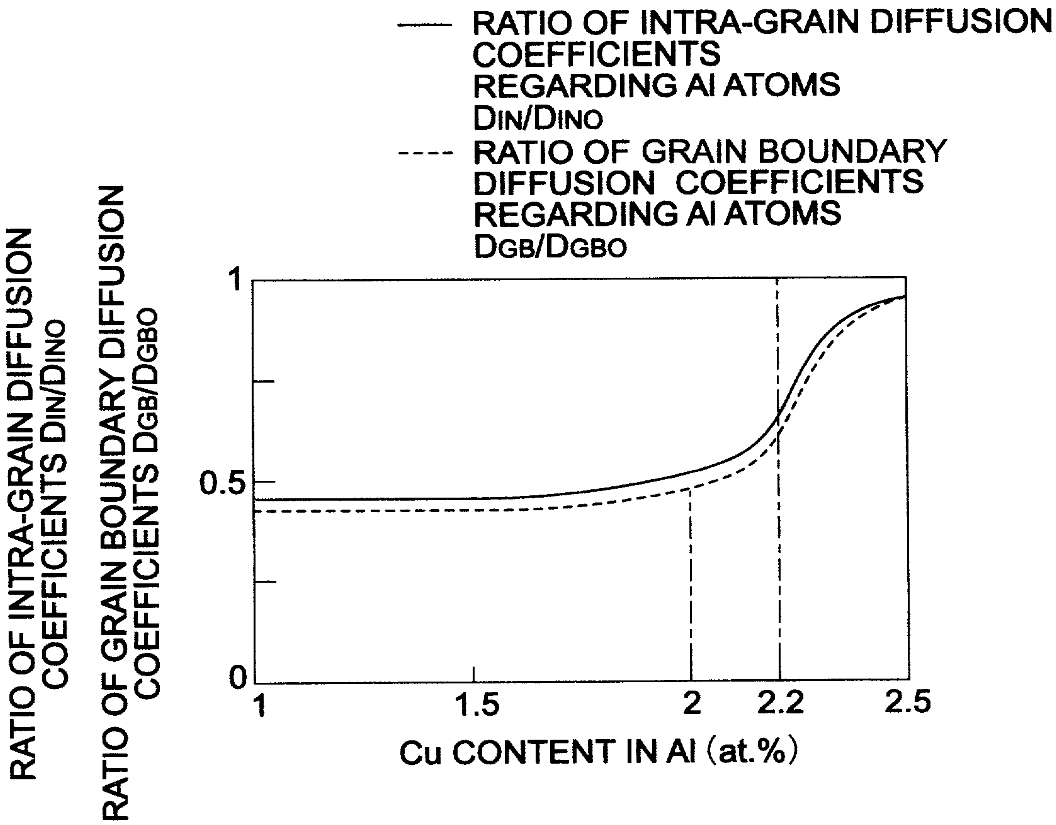
0
0
0.01
0.02
0.04
0.06
Cu CONTENT IN Al (at.%)

FIG. 3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RATIO OF GRAIN BOUNDARY DIFFUSION COEFFICIENTS REGARDING Al ATOMS DGB/DGBO
RATIO OF INTRA-GRAIN DIFFUSION COEFFICIENTS DIN/DINO
RATIO OF GRAIN BOUNDARY DIFFUSION COEFFICIENTS DGB/DGBO
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1
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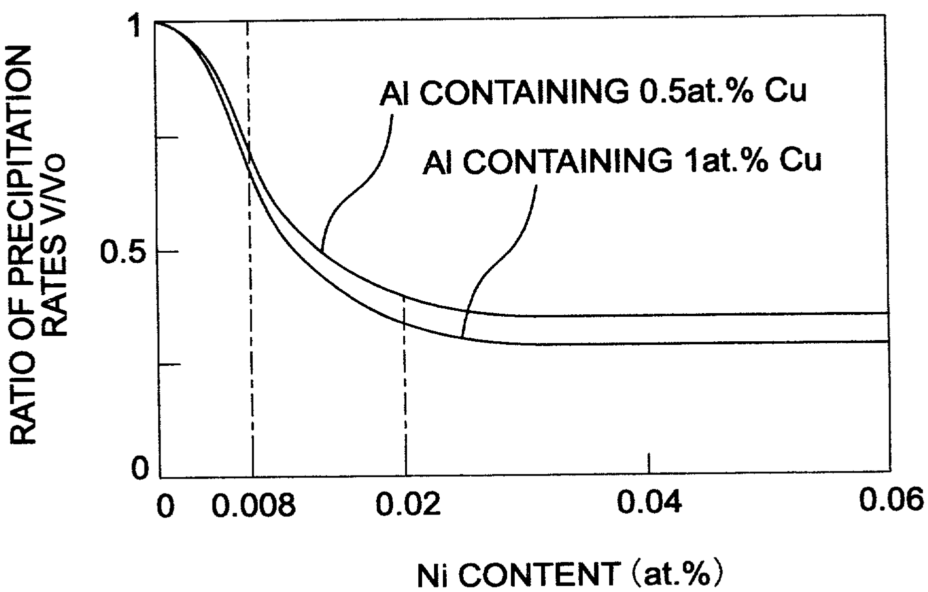
2.5
Cu CONTENT IN Al (at.%)

FIG. 4



RATIO OF PRECIPITATION RATES V/Vo
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Al CONTAINING 1at.% Cu
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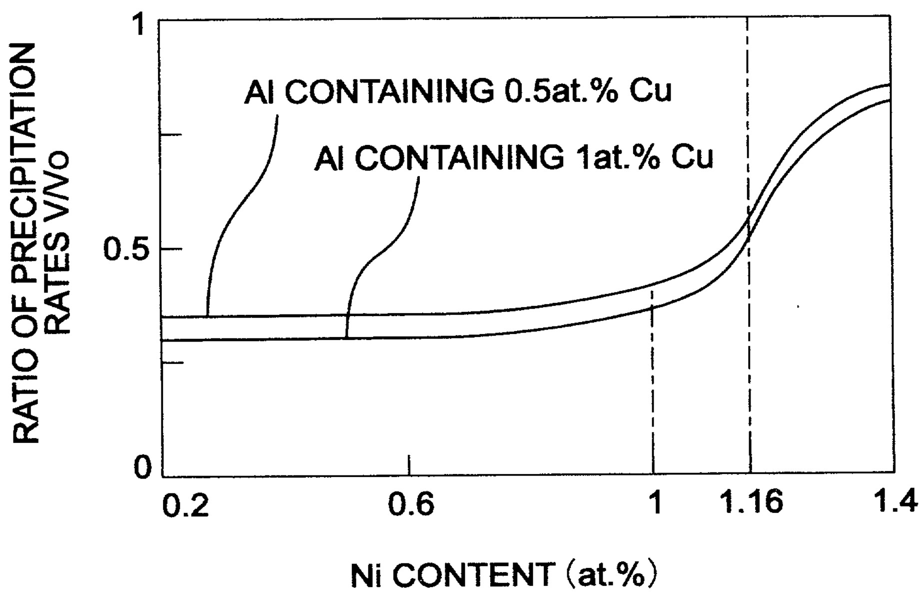
0.008
0.02
0.04
0.06
Ni CONTENT (at.%)

FIG. 5



Al CONTAINING 0.5at.% Cu
Al CONTAINING 1at.% Cu
RATIO OF PRECIPITATION RATES V/Vo
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0.2
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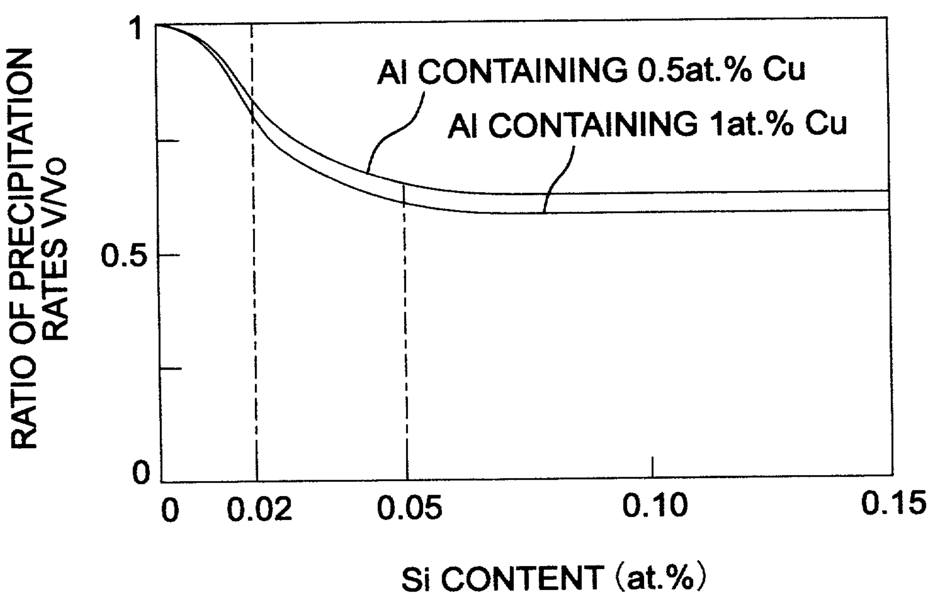
1
1.16
1.4
Ni CONTENT (at.%)

FIG. 6



1
0.5
0
RATIO OF PRECIPITATION RATES V/Vo
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AI CONTAINING 1at.% Cu
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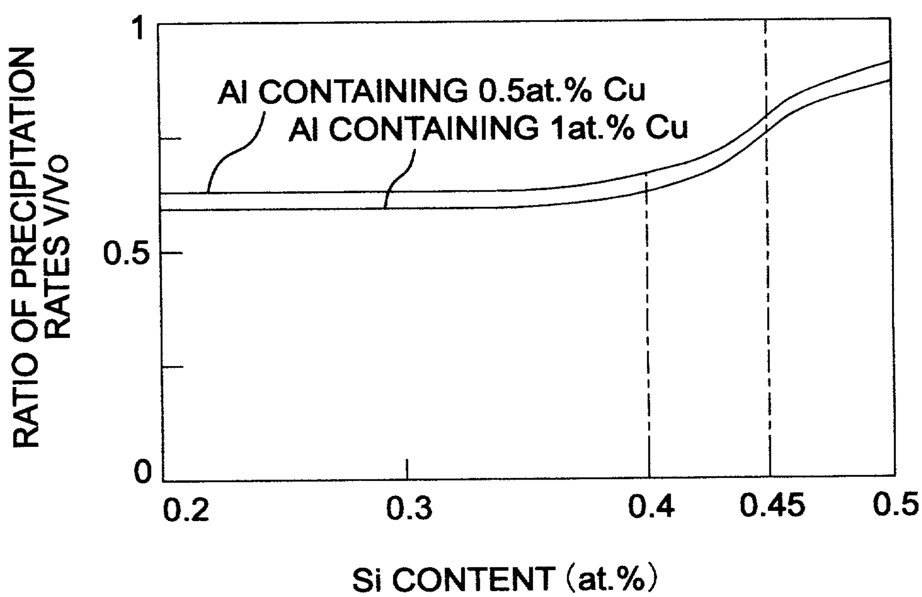
0.02
0.05
0.10
0.15
Si CONTENT (at.%)

FIG. 7



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Al CONTAINING 1at.% Cu
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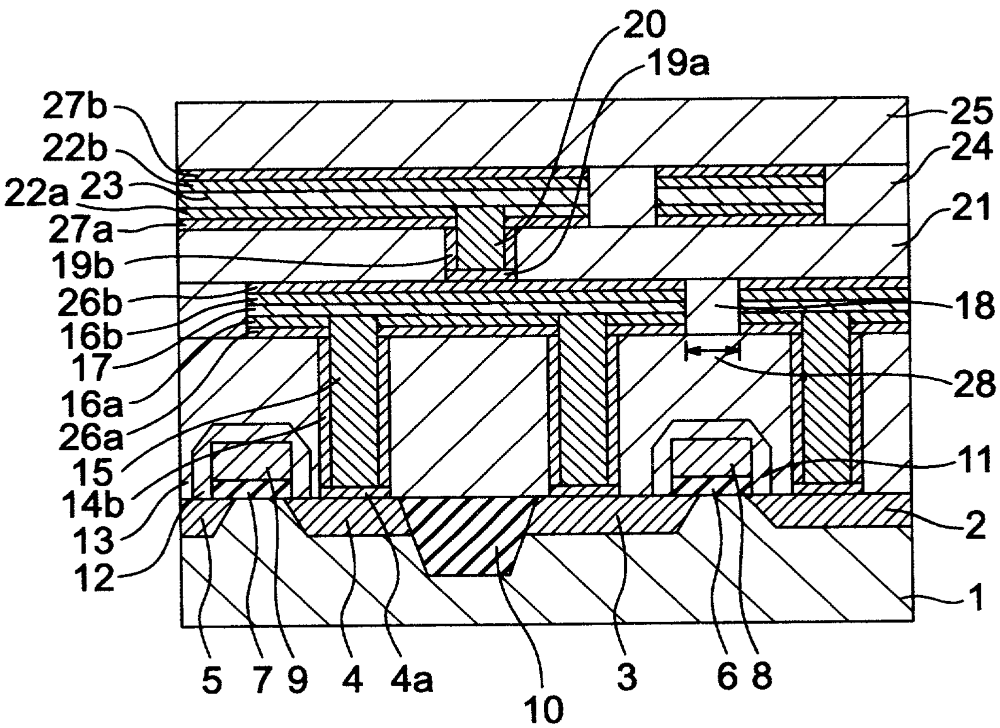
0.4
0.45
0.5
Si CONTENT (at.%)

FIG. 8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26a
15
14b
13
12
25
24
21
18
28
11
2
1
5
7
9
4
4a
10
3
6
8

FIG. 9

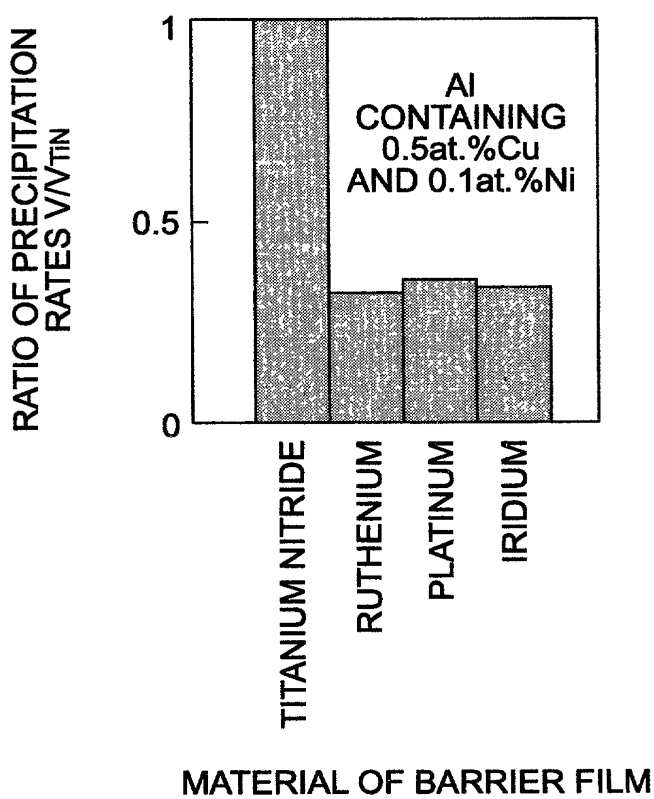
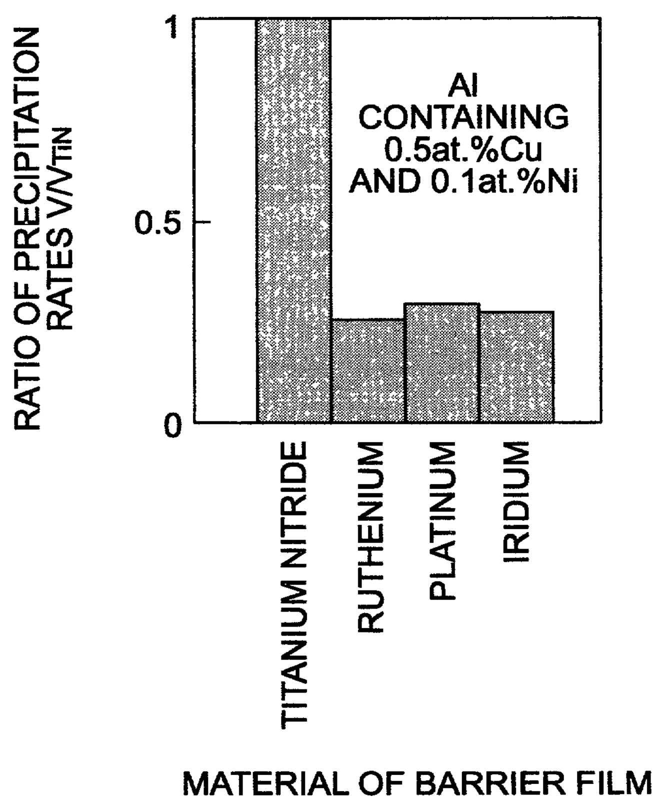

RATIO OF PRECIPITATION RATES V/V_TiN
1
0.5
0
Al
CONTAINING
0.5at.%Cu
AND 0.1at.%Ni
TITANIUM NITRIDE
RUTHENIUM
PLATINUM
IRIDIUM
MATERIAL OF BARRIER FILM

FIG. 10


RATIO OF PRECIPITATION RATES V/V_{TiN}
1
0.5
0
Al
CONTAINING
0.5at.%Cu
AND 0.1at.%Ni
TITANIUM NITRIDE
RUTHENIUM
PLATINUM
IRIDIUM
MATERIAL OF BARRIER FILM

E5346-01
(米)

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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

"SEMICONDUCTOR DEVICE"

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ ＿月＿日に提出され、米国出願番号または特許協定条約国際出願番号を＿＿＿＿＿とし、(該当する場合)＿＿＿＿＿に訂正されました。

☐ was filed on
as United States Application Number or
PCT International Application Number
＿＿＿＿＿ and was amended on
＿＿＿＿＿ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

E5366-01
(米)

Japanese Language Declaration
(日本語宣言書)

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I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
11-310641	Japan	1/November/1999	☐
			☐

私は、第３５編米国法典１１９条 (e) 項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

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(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条 (c) に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

E5366-01
(米)

Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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発明者の署名 日付	Inventor's signature Date Tomio Iwasaki Jul. 10, 2000
住所	Residence Tsukuba, Japan
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

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第二共同発明者の署名 日付	Second inventor's signature Date Hideo Miura Jul. 10, 2000
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第三共同発明者	Full name of third joint inventor, if any Takashi NAKAJIMA
第三共同発明者の署名 日付	Third inventor's signature Date Takashi Nakajima Jul. 10, 2000
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国籍	Citizenship Japan
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第四共同発明者	Full name of fourth joint inventor, if any Hiroyuki OHTA
第四共同発明者の署名 日付	Fourth inventor's signature Date Hiroyuki Ohta Jul. 10, 2000
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国籍	Citizenship Japan
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第五共同発明者	Full name of fifth joint inventor, if any Shinji NISHIHARA
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国籍	Citizenship Japan
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(Supply similar information and signature for sixth and subsequent joint inventors.)

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第六共同発明者	Full name of sixth joint inventor, if any Masashi SAHARA
第六共同発明者の署名 日付	Sixth inventor's signature Date Masashi Sahara Jul. 11, 2000
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国籍	Citizenship Japan
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第七共同発明者	Full name of seventh joint inventor, if any
第七共同発明者の署名 日付	Seventh inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address
第八共同発明者	Full name of eighth joint inventor, if any
第八共同発明者の署名 日付	Eighth inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address
第九共同発明者	Full name of ninth joint inventor, if any
第九共同発明者の署名 日付	Ninth inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address

(第十以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for tenth and subsequent joint inventors.)